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RESOURCE FACTORS AFFECTING THE FEASIBILITY OF PULP MILLS IN EASTERN MONTANA

by

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FOREWORD

This report which presents some of the resource information relating to pulp-mill development east of the Continental Divide in Montana has been prepared as part of a Forest Service program of interpreting Forest Survey data for public use. We feel that from such objective analyses will come sounder development of the timber resource. The report should not, of course, be regarded as official Forest Service endorsement of Eastern Montana as a pulp-mill site in preference to other parts of the United States and Alaska.

In addition to considering the quantity, availability, and cost of pulpwood, attention has been given to water supply from a pollution standpoint. At the request of the Montana Board of Health, L. F. Warrick and H. A. Anderson of the United States Public Health Service, Washington, D. C., made a reconnaissance survey of the streams in this area. A few of the highlights of their study are contained in this report. A more complete summary of their findings has been prepared by the Montana Board of Health and may be obtained by writing that office at Helena, Montana.

Experts from several different fields were called upon to aid in the study. They are too numerous to list here. However, particular credit is due I. V. Anderson of this Experiment Station, R. C. Setterstrom, representing the Industrial Development Division of the Montana Chamber of Commerce, and C. W. Brinck and H. B. Foote of the Montana Board of Health. These men actively participated with the U. S. Public Health Service in making the water pollution survey. C.W.West, L.M.Stewart, F. B. Casler, Harold H. Hendron, and S. H. Larson of the Forest Service gave invaluable assistance in the analysis of road development and wood procurement costs.

H. W. CAMP, Jr., Chief
Division of Forest Economics

INTRODUCTION

Few industries in the United States have grown so rapidly or as much as the industries which produce wood-pulp products. Indispensible for civilized existence anywhere, pulp products have carved an especially important niche for themselves in the United States. Books, clothing, magazines, paper cups, wall board, plastics, packaging, and a myriad of other items have added both to the efficiency of industry and to the comforts of life. Paper has been called the "pacemaker of progress," a statement which would be equally true if it were broadened to include all of the products made from wood pulp (2).

The mushrooming market during the past half century shows up in statistics of paper and paperboard mills in the United States. In 1899 these mills consumed 1.2 million tons of wood pulp. During the next 20 years their consumption tripled and each decade since then has been marked by a new high. By 1950 wood pulp consumption had climbed to 16.5 million tons--14 times higher than in 1899. In 1950 the sales of pulp, paper, and paperboard mills amounted to 6.7 billion dollars, to make this the sixth largest industry in the United States. Figure 1 shows the growth of the industry in terms of the wood consumed.

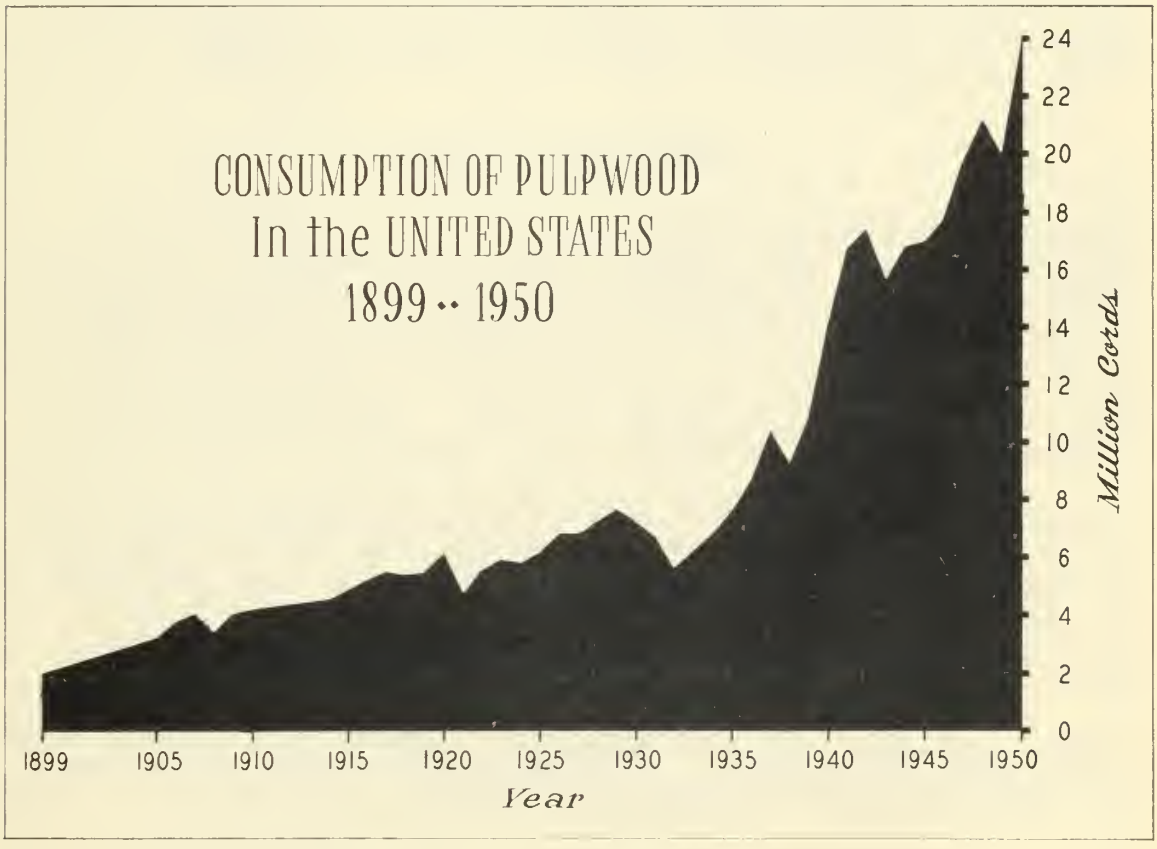


Figure 1.

The tremendous consumption of pulp products in the United States puts this country well ahead of the rest of the world. It seems almost unbelievable that with but 6 percent of the world's population we use something like half of the total output of wood-pulp products. During 1947 the world consumption of these products was but 31 pounds per person as compared with 251 pounds in the United States.

One of the remarkable features of the situation is that, although the United States uses more wood pulp than any other country, the market is still not permanently saturated. We are told that the long-run outlook is for the demand in this country to continue to grow. Certainly there has been no faltering in the upward trend of consumption such as would suggest that it had begun to level off once and for all. Rettie and Hallauer have made long-range estimates of wood needs in the United States. It is their opinion that if the population of this country rises to 167 million people, if we continue to enjoy a high level of prosperity, and if we continue to find new uses for wood-pulp products at the rate anticipated, the demand for wood pulp in the United States at the end of the century may be more than twice as high as it was in 1944 (5).

These predictions are significant, of course, because they indicate that the United States pulp and paper industry may continue to expand for a long time yet. The outlook has an additional significance to people in the Rocky Mountain states. It keeps alive the hope that this region may some day have a sizeable pulp products industry.

DEVELOPMENT IN MONTANA

Montana's pulp and paper history goes back a half century to the Manhattan Pulp and Paper Company at the town of Manhattan. The mill of this Company was built between 1900 and 1902 with machinery from an abandoned plant in Kentucky. W. A. Clark, an outstanding figure in Montana history, was one of the principal stockholders in this concern. According to Jesse Green, a student of Montana history, "The mill was set up to make paper out of straw. This material was very abundant in the Gallatin Valley in those days of the threshing machine.

"The plant began operating in 1902 and after a brief run it was concluded that the equipment and the knowledge of the operators were not sufficient to make paper from straw. As nearly as I can learn their vats were not correctly designed or were not large enough to bring straw into the right state to produce paper. About $300,000 were spent on the first venture.

"After a period, efforts were again made to operate--this time on wood pulp shipped from Wisconsin. A certain amount of newsprint and wrapping paper was made from the imported pulp.

"On the second trial E. W. King and Sellers Langey put up most of the funds which again amounted to $300,000. They were courageous men but the odds were against them. The freight on wet pulp from the east made the cost of the pulp more than the value of the paper they produced. The plant ran intermittently until about 1905 when it was finally shipped to some other point. The old brick and stone walls are a silent reminder of the wheels that once really turned out paper." 1/

Some of the equipment from the Manhattan mill ended up in the plant of the Inland Empire Paper Company, built in 1911 near Spokane, Washington.

With the exception of this brief experiment, Montana has had no pulp and paper industry. In fact, so far as we know, the first and only pulp mill manufacturing local timber in the Rocky Mountain states did not start until 1951. This is the mill of Potlatch Forests, Incorporated at Lewiston, Idaho.

Anyone who thumbs through the newspaper files for the past 50 years will find a number of references to proposed wood-pulp mills in this region. However, none of these high hopes ever really materialized until the Lewiston, Idaho plant was constructed. The reason is obvious. Although the Rocky Mountain states contain the largest undeveloped timber area in the continental United States, they have certain major handicaps. They have lacked the population to provide a large market for the products of such plants. Most of their timber is a long freight haul from the principal consuming centers of the country. This has constituted a big competitive disadvantage in relation to other more strategically located timber areas. Moreover, the rugged topography of the Rocky Mountains tends to make it fairly expensive to open up and log the timber chances. Still another factor is that technological progress in pulping techniques has made it possible for the industry to use less desirable timber in the regions where mills are already established rather than by a mass expansion into this territory. Whatever the causes, only one plant has been attracted to the Rocky Mountain region up to the present. How many more will be built in the next several decades? The answer to this question will mean a great deal to these states.

In the past few years there have been some fundamental changes in the economic picture. The far West is experiencing a dramatic population and industrial growth which is creating a larger nearby market for Montana timber. We have also seen a tightening of the timber supply situation over the United States as a whole. Wood-using industries are finding it increasingly difficult to satisfy their timber needs. Wisconsin pulp mills, for example, obtained almost 50,000 cords of pulpwood from Montana in 1950. The fact that they are reaching out more than 1000 miles into Montana is striking evidence of a wood pinch. West Coast plants have also begun to ship wood out of the Rocky Mountains. In the South, where most of the expansion has taken place in recent decades, pulp mills have become crowded to the point where it is increasingly difficult for new plants to stake out a supply of raw material.

1/ From a letter written to the Northern Rocky Mountain Forest and Range Experiment Station.

Predicting is at best a hazardous occupation and we must always recognize the possibility that situations may change. For example, if it becomes profitable to make widespread use of hardwoods we might see considerable further expansion of pulp-mill capacity in the South and East. Nevertheless, events of recent years have enhanced the prospects of a large pulp and paper mill expansion in the Rocky Mountain states. The 8 states in this region contain one of the last great reservoirs of undeveloped timber in the country. We have here 10 percent of the commercial forest land in the United States, and 14 percent of the softwood saw timber, including several species highly desirable for pulping.

PURPOSE OF THIS REPORT

With one pulp mill already going strong in North Idaho the question no longer is whether there will be a wood-pulp industry in the region, but rather how much development will take place. John A. Guthrie in his book, The Economics of Pulp and Paper, points out, "The future development of the pulp and paper industry in the United States hinges very largely on the possibility of obtaining an ample supply of cheap pulpwood." The Rocky Mountain states have the wood. How much of that wood will be cheap enough to be attractive to the pulp industry is still the big question.

The prospect that more pulp mills might be constructed in the Rocky Mountains during the coming few years has excited many people. Some are enthused by the thought of the employment and income these plants would create. A 200-ton sulfate pulp mill would, for example, employ about 450 men. If in addition the pulp from that plant were made into paper and paper products locally, another 900 men might be added to the pay roll. Private forest landowners and public land-managing agencies have much to gain from the establishment of pulp mills because such plants would provide an outlet for kinds of timber for which there is now no market.

On the other hand, some individuals point with alarm to the drawbacks of pulp mills. Such plants create water and air pollution problems. Especially serious damage can be done to our water resource. The answer lies in the fact that properly planned and guided pulp-mill development can bring many advantages to the region with a minimum adverse effect.

The purpose of this report is to provide some of the information required for sound planning in one part of the Rocky Mountains, namely the area east of the Continental Divide in Montana. For convenience this area will be called Eastern Montana. We shall examine the timber in Eastern Montana from the standpoint of its suitability, availability, and operability for pulpwood. The following chapters discuss the effect of pulpwood cutting upon the raw material supply of other timber industries. Water pollution aspects as they relate to development of the timber resource are also discussed briefly in this report.

The data in this report were carefully prepared but they are reconnaissance estimates based on certain assumptions. While this information is well suited for over-all planning purposes more intensive and complete studies will be necessary in planning for any pulp mill.

Approximately 44 percent of the forest land east of the Continental Divide in Montana appears to have commercial possibilities from a pulpwood standpoint.

The total forest area on this east slope is 9,300,000 acres. However, a large portion of it does not figure in the timber production picture at all. Some of it is formally reserved for recreational purposes (national parks and national forest wilderness areas). A larger portion up along the ridge tops is noncommercial and is primarily valuable for watershed protection. The total reserved and protection forest in Eastern Montana is 2,500,000 acres. This leaves 6,800,000 acres of commercial forest which can be used for the production of wood.

All of the timber on this 6,800,000 acres is potentially suitable for pulp, but in thinking of where it might be feasible for a pulp mill to get its wood our attention should be restricted still further. A substantial area of commercial forest occurs as thin stringers along many streams in farming and ranching areas and, therefore, will probably be mainly used for other purposes. The fringes of timber reaching out into the prairies tend to be too scattered and scrubby to be commercially attractive. Within the main forest zone, timber along many roads and streams should be subject only to restricted utilization to protect recreational values. The ponderosa pine stands are probably more valuable for lumber or other purposes than for pulpwood. If we drop all these areas the potential pulpwood land shrinks to 4,100,000 acres, or 44 percent of the total forest. Figure 2 shows the general area in Eastern Montana where we feel pulpwood cutting may be feasible.

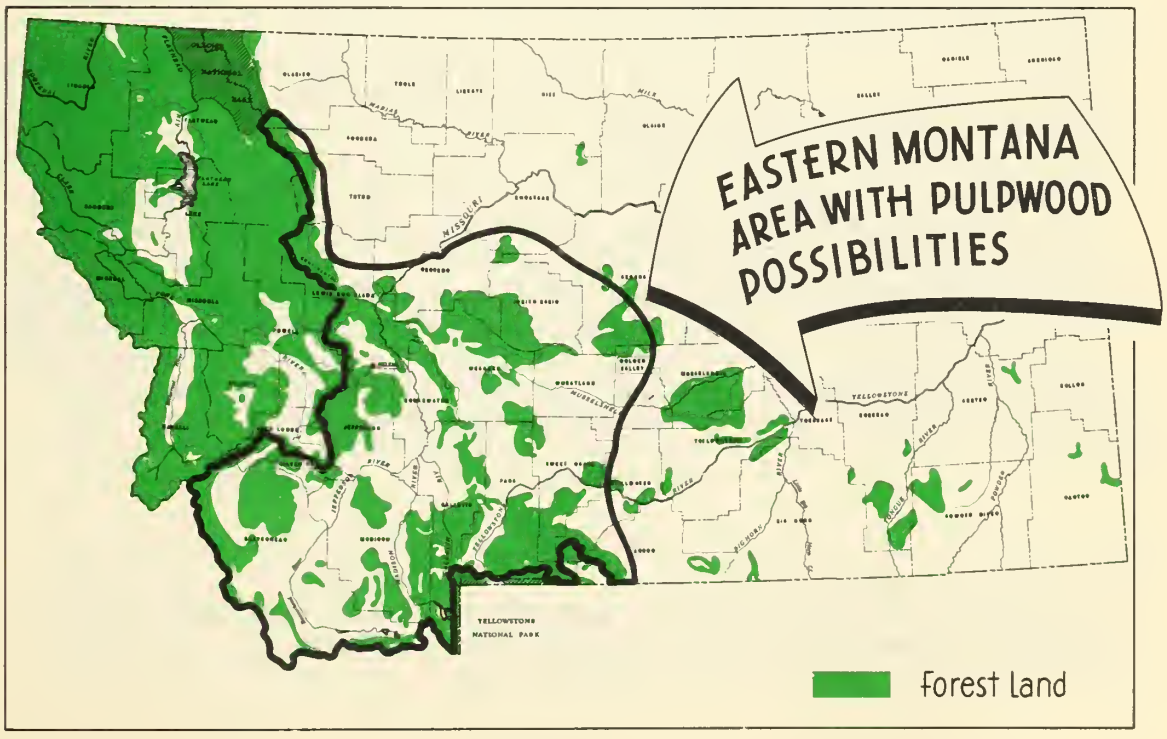


Figure 2.

If this 4 million acres of commercial forest is properly managed it can produce more than 1 million cords of timber annually.

If we were in a position to make full use of the productive capacity of the land, including the large volumes going to waste each year, the sustainable annual cut would be 1,038,000 cords. 2/ This is approximately one-fourth of a cord per acre per year which is a fairly low figure. With good forestry we should be able to produce that much annually forever in the future.

Approximately six-tenths of the sustainable cut is lodgepole pine, two-tenths Douglas-fir, and one-tenth spruce. The cut also includes small volumes of several other species as table 1 shows.

Table 1. Total sustainable annual cut within the drainages considered in this study

	Cords
Lodgepole pine	650,000
Douglas-fir	227,000
Spruce	89,000
Alpine fir	39,000
Whitebark & limber pine	19,000
Ponderosa pine	9,000
Aspen	5,000
Cottonwood	Negligible
Total	1,038,000

A cut of 1,038,000 cords a year is justifiable and sustainable only if the timber is fully utilized, if the cutting is properly distributed, and if management and protection are intensified.

Table 1 should make it clear that the entire production cannot be taken from lodgepole pine timber. If only this species is to be utilized the cut at the most can be 650,000 cords. In other words, to sustain the cut at 1 million cords, other species have to be used in the amounts indicated in the table.

Likewise, if the loggers leave behind one-tenth or one-fourth or some other proportion of the usable timber on cutover areas to rot, the cut must be reduced proportionately.

This figure of 1,038,000 cords is in effect the maximum present productive capacity of the forest on a sustained-yield basis. Out of that figure we must take the trees that die as well as the ones cut. At present, man is using only a small part of the available timber, and insects, diseases, high winds, etc. are harvesting an even greater quantity of wood. Forest Survey men calculate that these destructive agents are now nullifying about one-eight of the total growth in Eastern Montana. Periodically the losses go much higher.

2/ Cords of rough wood, that is, they include bark.

It boils down to this: If the loggers are to harvest as much timber as possible without upsetting sustained yield, they must take much of that timber away from insects and other destroyers. It must be cut before it becomes susceptible to insect and disease attack or it must be salvaged within a reasonable time after it is killed. Thus, if logging is concentrated for long in only part of the forest, and losses continue on the rest, the actual cut may have to be kept considerably below the theoretically sustainable level. A major part of the forest in Eastern Montana is without roads and therefore unloggable today. As less than 1 percent of the needed national forest roads in the State are currently being constructed each year, it will be a long time, at the present rate, before the problem of accessibility is solved. Until road building is greatly accelerated we will not be justified in increasing the cut up to the full sustained-yield capacity of the forest.

Better distribution of logging operations will not alone solve the problem of timber losses. Protection needs to be tightened at the same time. Fire control in Eastern Montana has been relatively good. Comparable steps have not been taken to reduce disease and insect losses. Insects in particular have killed a tremendous volume of timber and unless adequate steps are taken to combat this problem much more timber will be lost. More intensive management is required all along the line. For example, mistletoe is a serious pest in many stands and measures to keep it in check must be intensified.

At the same time the roads are being built and protection improved these forests should be staffed to handle the business. National forest timber sales have lagged somewhat in recent years for lack of manpower to handle them. Inasmuch as operating funds do not come out of receipts but as appropriations from Congress, this may continue to be a problem. In any case before the full cut can be sustained from the national forests the timber management organization will have to be greatly expanded.

The main thing to remember about this 1,038,000 cords of sustainable cut is that it is by no means a bird-in-the-hand so far as the timber industries are concerned. To sustain that level of production we will have to do a better job of management and utilization.

<u>There is sufficient timber to support an expansion of other industries in addition to a new pulp and paper industry</u>.

Lumber, mine timbers, transmission poles, fuel wood, fence posts, and other products are cut from the forests of Eastern Montana. These are important uses and any pulp-mill planning should not be at the expense of future development of these industries.

Just how much of the volume of each species will be used by the various industries is, of course, impossible to say in advance of actual demand. However, certain assumptions in that regard were made in connection with this study. For example, it was felt that it would be unwise to consider any of the ponderosa pine as available for pulping

at this time because of the value of this species for lumber. On the other hand, the main hope for moving the lodgepole pine appears to lie in using a substantial part of it for pulp. However, there are increasing signs that some of the lodgepole pine may be used for lumber by edge gluing of boards to produce wide pieces from these small trees.

Table 2. Proportion of sustainable cut which it is assumed will be used for purposes other than pulp

Species	Percent
Lodgepole pine	20
Douglas-fir	50
Spruce	20
Alpine fir	0
Whitebark & limber pine	50
Ponderosa pine	100
Aspen	10
Cottonwood	100

Table 2 shows the proportion of each species which we assume will be required for other uses. These are, of course, over-all averages for purposes of analysis. For example, all of the lodgepole pine in some drainages might be used for pulping, whereas in other areas none would go to pulp mills.

The effect of these assumptions would be to remove approximately 279,000 cords a year, or one-fourth of the sustainable cut from pulp-mill planning as table 3 indicates. It is well to bear in mind that the 279,000 cords available for other industries in table 3 are only from the drainages being considered for pulpwood. All of the 2.7 million acres of commercial forest outside the pulpwood drainages would be available for other industries.

Table 3. Sustainable annual cut available for other industries in pulpwood units under assumptions of table 2

	Cords
Lodgepole pine	130,000
Douglas-fir	113,000
Spruce	18,000
Alpine fir	--
Whitebark and limber pine	9,000
Ponderosa pine	9,000
Aspen	Negligible
Cottonwood	Negligible
Total	279,000

We have no accurate information on the volume of timber now being cut for products other than pulpwood. It is estimated, however, that a cut of 279,000 cords would permit a fivefold expansion of lumber, pole, and mine timber production in this locality.

Figure 3. The cream of the pulpwood resource in Eastern Montana is lodgepole pine stands such as this.

After allowing for the possible future needs of other industries there are still 759,000 cords a year of green timber which can be cut for pulpwood. This is 16 times as much timber as was cut for that purpose in 1950.

During 1950 Wisconsin pulp mills shipped 48,000 cords of lodgepole pine out of Eastern Montana. As table 4 indicates this drain is relatively small in relation to the producing capacity of the forest. Whether the pulp and paper industries ever use three-fourths of a million cords of wood annually will depend on the willingness of the industry to use all of the different kinds of timber. Up to the present only the lodgepole pine has been consumed in any quantity. Use of more than one kind of wood complicates the pulp mill's task. However, as we will show later, all of these species are suitable for pulping and some of them make excellent pulp.

Table 4. Sustainable annual cut of green wood available for pulping under assumptions of table 2

	Cords
Lodgepole pine	520,000
Douglas-fir	114,000
Spruce	71,000
Alpine fir	39,000
Whitebark & limber pine	10,000
Aspen	5,000
Total	759,000

The potential pulpwood is scattered throughout the area outlined in figure 2. However, the principal available supply is located in the south central part of the State in and around the Beaverhead and Gallatin National Forests, as table 5 shows.

Table 5. Where the potential pulpwood timber is to be found

Land of all owners in the vicinity of:	Annual sustainable cut-cords
Beaverhead Natl Forest	254,000
Custer " "	22,000
Deerlodge " "	68,000
Gallatin " "	216,000
Helena " "	70,000
Lewis & Clark " "	129,000
Total	759,000

Figure 4 on the opposite page shows the location of the sustainable pulpwood cut by working circles. The figures for each of the 31 working circles, though they give an indication of where the timber is, should not be taken too literally because they assume that the same proportion of each species will be available for pulping each working circle. (For example, it has been assumed that 80 percent of the lodgepole pine in each drainage would be cut for pulpwood.) As we have pointed out the proportions actually will vary considerably from working circle to working circle. Likewise, it is well to remember that Forest Survey data, although quite accurate in total, have a fairly large margin of error for units as small as these.

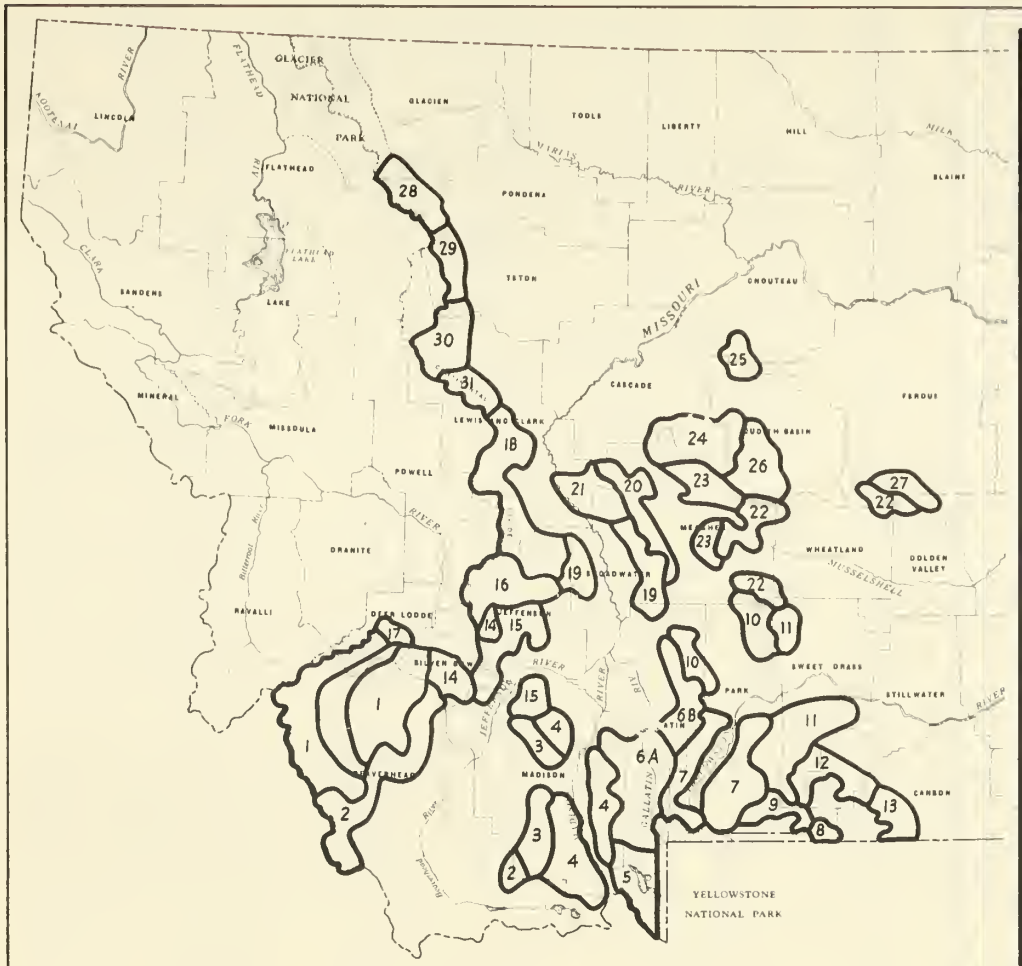
An annual cut of 759,000 cords would support 6 medium-size pulp mills.

A medium-size pulp mill is one producing 200 tons of pulp daily. Approximately 120,000 cords, or 4500 freight carloads of wood, are required annually to keep such a plant operating. There is enough green wood available for 6 mills of that size.

The large volumes of dead wood in Eastern Montana are not included in the preceding figures and, therefore, constitute an additional source of supply.

In the past half century the forests of Eastern Montana have been subjected to very heavy losses by insects, fires, and other causes. Most of that timber has long since rotted beyond usefulness. However, there is still a large volume nearly as sound as the day it died--in some cases more than 25 years ago. It constitutes a big backlog of material. The Forest Survey has estimated that the dead timber in Eastern Montana, plus the smaller quantity of sound wood in cull trees, could supply an annual cut of 290,000 cords of wood per year for the next 20 years (1). In other words, it could, if it were more concentrated, almost support a 500-ton pulp mill. Most of the dead and cull timber lies in the pulpwood units and, therefore, can be considered as available for pulping.

Figure 4



SUSTAINABLE ANNUAL PULPWOOD CUT
by working circles

WORKING CIRCLE		CORDS per YEAR
1	Big Hole	150,000
2	Beaverhead	54,000
3	Ruby	14,000
4	Madison	36,000
5	Madison Basin	33,000
6	Gallatin	81,000
7	Yellowston	37,000
8	Cooke	2,000
9	Absoroka	16,000
10	Shields	20,000
11	Big Timber	28,000
12	Beartooth	12,000
13	Rock Creek	9,000
14	Butte	10,000
15	Whitehall	23,000
16	Boulder	33,000
17	Anaconda	3,000
18	Helena	36,000
19	Townsend	15,000
20	Smith River	12,000
21	Canyon Ferry	7,000
22	Mussellshell	18,000
23	White Sulphur Springs	29,000
24	Belt Creek	22,000
25	Highwood	3,000
26	Judith River	9,000
27	Snowy Mountains	1,000
28	Marias	7,000
29	Teton	3,000
30	Sun River	18,000
31	Dearborn	18,000

Figure 4

Virtually none of the pulpwood now being shipped to Wisconsin plants is from dead and cull timber. That is, however, no sign that such trees are not suitable for pulping. It merely indicates that where raw material has to be hauled a long way it is difficult to get good utilization. Tests have shown that much of the dead timber in Eastern Montana will make good pulp, as the following excerpt from a recent publication by the Forest Products Laboratory at Madison, Wisconsin, indicates: "The green and sound dead woods (lodgepole pine) showed similar pulping characteristics and gave nearly the same pulp yields and pulp strengths. The dead wood with decay showed a slight tendency to pulp more rapidly and to give lower permanganate numbers, lower pulp yields and lower pulp strengths. The difference in yield was, however, only 5 percent, and in pulp strength, only 10 percent, between green wood and dead wood with 28.6 percent advanced decay." (6)

Any local pulp-mill development must take into account dead wood supplies. In parts of the Big Hole Basin and elsewhere it will not be feasible to log the green timber without taking the dead. Moreover, if all the usable wood is not cleaned up in any cutting operation, the logging debris creates a high hazard and makes it difficult to establish a new stand. It is, of course, no more than good business to use the dead and cull timber insofar as possible. Thus, though the timber yield estimates in this report do not include such material any pulp mills built in Eastern Montana should be expected to use a great deal of it.

Water is going to be the principal factor determining pulp-mill location in Eastern Montana.

Wood pulp mills use far more water than they do wood. A typical kraft plant producing 200 tons of unbleached pulp daily requires 7 million gallons of water a day. To process the same amount of bleached pulp takes 18 million gallons daily. Actually, however, the water used in processing the pulp is a minor quantity in comparison with the stream flow needed to handle the waste liquors, which consist of the pulping chemicals, some fibers, and large amounts of dissolved organic material. Some of the chemicals in sufficient concentration are poisonous. The fibers, if present in any quantity, blanket the stream bed. The organic material draws oxygen from the water in the course of its decomposition. Oxygen depletion, if it goes far enough, kills desirable forms of aquatic life and creates a foul, malodorous condition.

The waste pulping liquors of even a small plant are sufficient to wreck a little stream.3/ Comparatively large flows are required to dilute the wastes to the point where they are harmless. Just how large the streams should be can be judged from the fact that the waste of the average 200-ton sulfite pulp mill, using the calcium base process, produces pollution equivalent to the sewage of 700,000 people, on the basis of oxygen demand. The pollution equivalent of the average 200-ton sulfate or kraft mill built before World War II is about 80,000 people.

3/ The pollution problem of the pulp and paper industry is mainly in the pulping stage.

Great advances have been made by the pulp and paper industry in overcoming this serious drawback of pulp mills. For example, processes have recently been developed for substituting magnesium or ammonia for calcium in the sulfite plants, thereby making it possible to drastically reduce the quantities of harmful substances dumped into the streams. The quantity of toxic chemicals leaving some kraft mills has been reduced by installation of "Bergstrom towers," and other improvements for chemical recovery. An increasing number of plants are storing waste liquor in lagoons during low-water periods. These are but a few of the developments. All of the pulp mills, of course, are looking for ways to profitably use the liquor now being thrown away.

So far as wood procurement costs are concerned, it would be desirable to have the pulp mills located on some of the secondary streams fairly close to the timber. However, despite the advances in solving the pollution problem, not enough progress has been made to justify building modern-size pulp plants on any but the major streams. In the estimation of the Montana Board of Health and the United States Public Health Service, the prudent course at this time is to confine pulp-mill development in Eastern Montana to the Missouri River from Three Forks down, and to the Yellowstone River below Livingston.

No pulp mill should be built in Eastern Montana without a thorough analysis of the stream flow in relation to the size and character of the contemplated plant. However, for the purpose of getting a general picture of the pollution problem as well as an estimate of transportation costs, five possible sites were picked for preliminary analysis: Three Forks, Winston, Great Falls, Livingston, and Billings. At the request of the Montana Board of Health the United States Public Health Service made an extensive survey of these sites. Results of the survey are described in the publication mentioned in the Foreword of this report. Briefly, the following conclusions were reached:

Billings is not, at present, a desirable pulp-mill site because there is already excessive pollution in the Yellowstone River at that point. Reduction of existing pollution would, of course, modify the picture. Modern 200-ton kraft mills could be operated at Great Falls and Livingston without materially damaging the stream. Likewise, one could be operated at either Three Forks or Winston without serious damage. Whether 200-ton plants could be located at both Winston and Three Forks is a matter which would require further study. The oxidation of the waste in both cases would take place mainly in the Canyon Ferry reservoir and the total effect of two such plants might create an intolerable degree of pollution. Pollution problems might be slightly greater for a mill at Winston than for one at Three Forks because of slack water at the former location.

The pollution survey indicates that the principal problem with regard to kraft mill wastes is adequate dilution of such toxic chemicals as may reach the stream. If these chemicals are discharged at a uniform rate and evenly distributed throughout the stream, no adult fish are likely to be killed nor domestic water supplies damaged. However, at low flows of these streams the chemicals may be strong enough to cause some reduction of fish food organisms and therefore a decline of the fish population. There may also be some reduction of spawning areas. These two problems are more likely to be serious at Livingston than at the other sites considered. This does not eliminate Livingston as a possible pulp-mill site. It does indicate, though, that pulp-mill development at this point should proceed with particular caution.

No attempt was made to determine how much mill capacity might be safely put at each of these several points from a pollution standpoint. Nor was any consideration given to the possibilities of ammonia base or magnesium base sulfite mills (calcium base sulfite pulp mills are presently out of the question from a pollution standpoint). However, the study has established two facts quite clearly: (1) Kraft pulp mills can be operated on these stretches of water without causing excessive damage. (2) The margin of safety, nevertheless, is not great and vigilance is necessary to avoid serious pollution.

Whatever mills are constructed should be expected to adopt the latest equipment, devices, and techniques to reduce the volume and potency of the waste. They also should be expected to control the rate of flow of waste into the rivers so that it will do as little damage as possible.

The public also has a responsibility with regard to industrial pollution. Legislation is needed to permit the people of Montana to take the lead in protecting the water supplies which mean so much to this State.

There is ample timber tributary to each of these possible mill sites but to get enough for a pulp mill will require rather full development of the resource in several cases.

With full development of the timber and the division of wood between industries which we have assumed, more than 400,000 cords per year of pulpwood would be available at Three Forks. A somewhat smaller total quantity would be available at Great Falls and Livingston together as table 6 indicates.4/

The minimum economic size for pulp mills is generally regarded as 150 to 200 tons of pulp per day. Such mills require from 90,000 to 120,000 cords of wood yearly. Thus, the volume tributary to each of these points is more than enough to sustain a pulp mill, without taking account of the dead wood. To get enough wood, however, will require use of other species in addition to lodgepole pine.

4/ Billings has not been included as one of the pulp-mill sites here because of the existing pollution on the Yellowstone River at this point. Until there is assurance of lower pollution rates, Winston should be considered only as an alternate site to Three Forks.

The sustainable cut in table 6 was in the main allocated between the three sites on the basis of cost of delivery--that is, considering it tributary to the point to which it could be delivered most cheaply, although in some instances the differences between points are not very great. An exception was made in the case of working circles 19 and 21 (figure 4) which were considered tributary to Great Falls even though the wood in them could be delivered somewhat more cheaply to Three Forks. The exception was made because of the greater volume of wood available to Three Forks.

Table 6. Annual sustainable green pulpwood cut tributary to each of three mill sites

	All species	Lodgepole pine
	--Cords--	
Three Forks	442,000	319,000
Livingston 5/	127,000	82,000
Great Falls	172,000	108,000

It is well to remember that there are a number of ways which the pulpwood resources in Eastern Montana might be divided depending upon how and where the industry develops. The figures in table 6 show one distribution under a given set of circumstances.

The opportunity for establishing pulp mills at the points shown in table 6 is not so much dependent upon the magnitude of the total allowable cut figures in that table, as it is upon the proportion of this wood volume which can be made available in the coming few years. For example, if it is possible to develop only half of the forest area tributary to Livingston during the next decade the sustained yield cut in that area would be insufficient to support a 200-ton pulp plant. A great deal depends upon the aggressiveness with which the management and utilization problems, already discussed, are tackled.

The timber tributary to Three Forks is adequate to ultimately supply 700 tons of kraft-mill capacity. This raises the question whether the Missouri River at that point can handle as large a mill as the timber can supply. This question cannot be answered without considerable additional study. It further emphasizes, however, the desirability of building and operating pulp mills which contribute as little as possible to the pollution problem.

The ownership of the 4-million acres of commercial forest in the pulpwood units is such as to favor systematic utilization and management of the timber.

The timber land holdings in the pulpwood units of Eastern Montana are predominantly large and relatively few in number. From a purely forestry standpoint that situation gives Montana a decided advantage over some localities, for the problem child of American forestry is the small landowner. To say it differently, the possibilities of getting good forest management and coordination of effort between owners are greatly enhanced by the fact that so much of the total area is in a few large holdings.

5/ Does not include 18,000 cords in working circles 8 and 9 which are presently unavailable because they would have to be hauled through Yellowstone National Park.

Table 7 shows that seven-tenths of the commercial forest area in these 21 counties, which include practically all of the pulpwood area, is federally owned in the national forests. Though one-fifth of the forest is privately owned a big part of that belongs to one owner, the Northern Pacific Railroad.

Table 7. Ownership of commercial forest land in the 21 counties including most of pulpwood units

	Acres
National forest	3,540,000
Public domain	250,000
Other federal	10,000
State and county	100,000
Private	1,140,000
Total	5,040,000

An even higher proportion of the desirable pulpwood timber in the 21 counties is on the national forests--85 percent of the lodgepole pine type and 95 percent of the spruce type.

Perhaps the most pressing ownership problem is the checkerboard pattern of alternate public and private lands, occurring in places as a result of the Northern Pacific Railroad land grant. The problem is principally on the Gallatin National Forest but it also occurs elsewhere.

At best such intermingled holdings complicate management. In this part of Montana, where development costs are high and timber values comparatively low, the problem is even more important, but by no means insoluble. The forest in checkerboard areas is not worth enough to support two separate logging operations or a logging operation on half the timber. Attempts are being made, therefore, to unscramble the holdings through land exchange. Where that is not done there will need to be close coordination between the various owners.

An orderly development of the pulpwood resource is desirable.

The prospect of a big industrial expansion all at once is a temptation to everyone who stands to gain by it. However, national forest administrators point out the desirability of proceeding with a certain amount of caution. Pulp plants, wherever they are located, will have a big impact upon their communities and upon forest management. Much is yet to be learned about handling this large timber business on the national forests so as to produce the greatest benefit to local communities. This forest produces recreation, water, domestic grazing, and wildlife. It would be a mistake to sacrifice these other uses for timber production. It is especially important from a watershed standpoint not to rush headlong into the utilization of some of the so-called "sensitive areas." These are areas of steep slopes and unstable soil conditions which might be damaged by present logging methods. While all of them will no doubt eventually be loggable there is still a lot to be learned about their management and use.

An orderly pulp-mill development is likewise desirable from a water pollution standpoint as the degree of success of various pollution abatement measures can in the end be determined only by experience.

ESTIMATED PROCUREMENT COSTS

The calculated average cost of pulpwood laid down at these mill sites ranges from $19 at Livingston to $22.50 at Three Forks.

These costs, based on 1950 prices, are shown in table 8. The average cost of the individual working circle is shown in figure 5. Whether the costs are low enough to be attractive to pulp companies can, of course, only be told by the companies themselves, for they have the data on mill costs and market values. However, the figures in table 8 are undoubtedly higher than in some other regions.

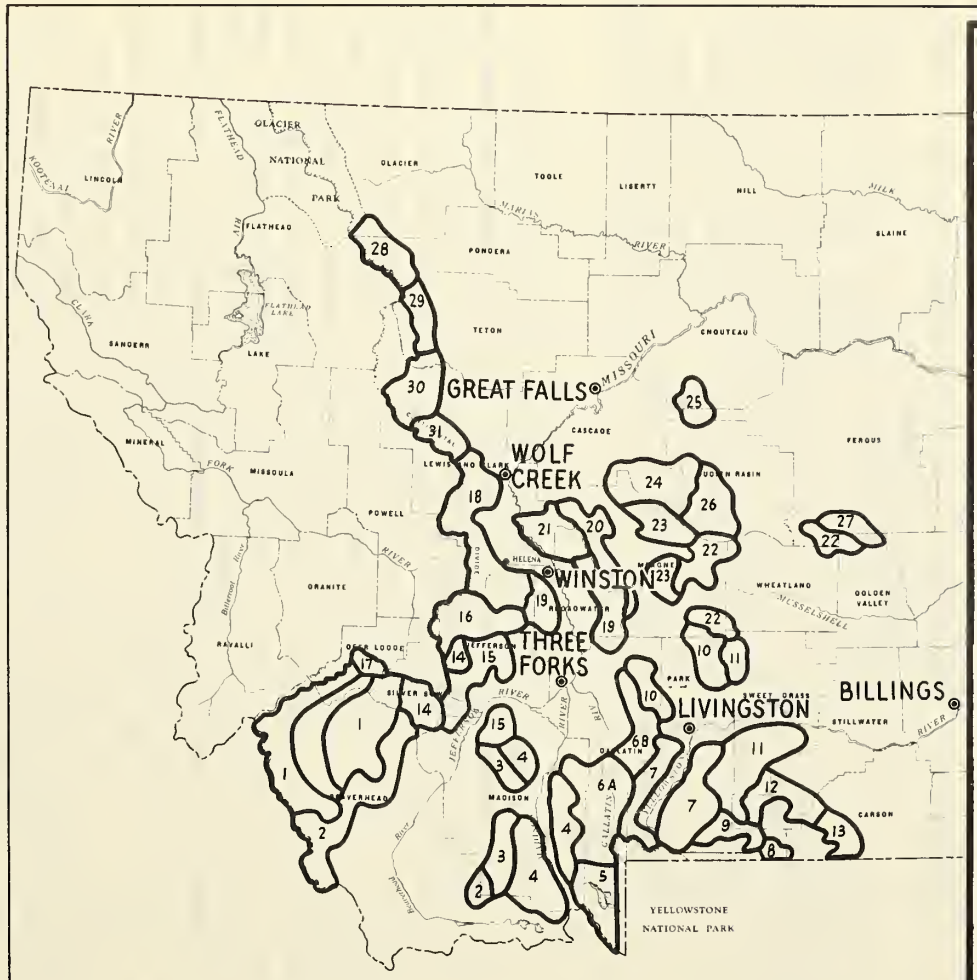
Table 8. Average cost of pulpwood delivered to mill sites

	Great Falls	Three Forks	Livingston
	- Dollars per cord -		
Road construction	.93	.59	.79
Hauling and road maintenance	8.25	9.23	5.99
Logging	8.70	8.70	8.70
Margin for profit and risk	1.94	2.02	1.71
Stumpage and timber stand improvement	2.00	2.00	2.00
Total	21.82	22.54	19.19

A recent study of pulpwood production in Southeast Arkansas during 1950 shows a cost per cord of $11.14 delivered to the railroad car or pulp mill (not including stumpage) (4). An exact comparison cannot be made but we can get some idea of the differences between the two regions from the fact that to log the timber tributary to Three Forks and transport it to the nearest rail siding would cost an average of $16.86 a cord.

Rough topography is one of the factors making for high procurement cost. That disadvantage is partly offset by fairly heavy volumes per acre. The average mature lodgepole pine stand, for example, has more than 25 cords of wood per acre. Another disadvantage is the undeveloped condition of the country which requires a large expenditure for road building. A far more important handicap, however, is the long distance between the timber and any mill sites presently suitable from a water supply standpoint. Table 8 shows that not only is transportation a major item of cost, it is the principal variable in costs between these several sites. Eastern Montana is a semi-arid country with its greatest precipitation at the higher elevations. As a consequence the principal timber stands are located in the mountains, whereas, pulp-mill sites because of the stream-flow requirements tend to be limited to a few stretches of river out in the valley a long way from the timber. Three Forks, though it is more than 150 miles from some of the timber we call tributary to it, is the closest point to this timber with sufficient water for a kraft pulp mill using present known practices.

Figure 5



COST OF PULPWOOD DELIVERED TO MILLSITES

DESTINATION	WORKING CIRCLE		DELIVERED COST per CORD
GREAT FALLS	16	Boulder	$20.39
	18	Helena	20.24
	19	Townsend	22.39
	21	Conyon Ferry	21.82
	24	Belt Creek	24.04
	25	Highwood	21.21
	26	Judith River	24.01
	27	Snowy Mountains	22.38
	28	Morios	22.87
	29	Teton	22.27
	30	Sun River	22.74
	31	Dearborn	22.01
THREE FORKS	1	Big Hole	24.70
	2	Beaverhead	24.73
	3	Ruby	22.33
	4	Madison	20.49
	5	Madison Basin	22.85
	6A	Gallatin (South)	19.70
	14	Butte	20.83
	15	Whitehall	18.46
	17	Anaconda	22.02
	20	Smith River	20.93
	22	Mussellshell	20.63
	23	White Sulphur Springs	20.73
LIVINGSTON	6B	Gallatin (North)	17.92
	7	Yellowstone	18.27
	8	Cooke	20.78
	9	Absoraka	24.01
	10	Shields	19.39
	11	Big Timber	19.57
	12	Beartooth	21.82
	13	Rock Creek	20.68

Figure 5.

The fact that some of the timber is a long way from these mill sites is actually less important from a cost standpoint than the fact that the average haul is long. There is little timber near these mill sites to bring down the average haul distance.

For example, there is very little timber closer than 50 miles from Three Forks. As a result the average haul is a little more than 90 miles. The average wood haul to the Great Falls mill site is likewise about 90 miles, and between 50 to 60 miles to Livingston.

Lack of rail facilities in some localities necessitates trucking timber farther than is economically desirable and is another factor adding to the cost of pulpwood. The Big Hole Basin above the town of Divide is an outstanding example of this. This Basin, an area of over 2000 square miles, hasn't a mile of rail line in it. Thus, though it would undoubtedly be cheaper to use rail transportation, if it were available, for distances in excess of 40 miles, some timber in the Big Hole is still as much as 80 miles from the nearest rail siding after it is brought out of the mountains into the main valley.

A heavy initial investment in roads is necessary to open this forest up for management and utilization.

As we have mentioned already, lack of roads is one of the principal handicaps preventing full use of the forest. To produce one million cords of wood a year from the 31 working circles will require the construction or reconstruction of 10,000 miles of main road at a cost of 48 million dollars. This will require a large-scale road building program. In the course of logging operations another 20,000 miles of short spur or feeder road will also be needed. This will cost some 27 million dollars at 1950 prices.

Table 9. Roads needing to be built or rebuilt to sustain the full cut from the 31 working circles

Area tributary to:	Miles	Thousand dollars
Primary and secondary roads		
Great Falls	3,157	15,175
Three Forks	5,056	23,416
Livingston	1,892	9,243
Total	10,105	47,834
Feeder roads		
Great Falls	6,824	8,502
Three Forks	9,842	11,780
Livingston	3,743	6,889
Total	20,409	27,171

DETAILS OF YIELD AND COST CALCULATIONS

The timber yields in this report are based on individual analyses of 296 management units in the pulpwood area.

A management unit as the term is used here is similar to the compartment of national forest terminology and is a topographically distinct area such as a major creek drainage. These units each have from 700 to 42,000 acres of loggable area and average about 14,000 acres. The data for the 296 units were subsequently grouped into 31 working circles which the Forest Service is using in its administration.

The annual sustainable cut by species for each management unit was determined by multiplying the area of each forest type in that unit by a calculated average allowable cut per acre by species for that type.

The commercial forest area in each unit was estimated by planimetering 1/2-inch-to-the-mile forest type maps made by the Forest Survey for each county.

These maps, prepared from aerial photographs, show the location of each forest type but give no information as to age of the timber, or site quality of the land. Because of the lack of this information and their small scale the maps are suitable only for general planning purposes.

Yields were calculated only for the area which will sooner or later be logged. In other words, noncommercial forest area and reserved lands in national parks, national forest primitive areas, roadside and streamside recreation strips have not been counted on for timber products.

Several drainages are the source of municipal water which is and should be the principal consideration in their management. However, as it is possible to log timber without impairing the quality of the water these drainages or units were included in the calculations.

The sustainable cut figures are based on rotations ranging from 80 to 200 years depending upon the timber type.

Following are the rotations used in the calculations:

Type	Rotation
Ponderosa pine	160 years
Douglas-fir	200 "
Spruce, lodgepole pine and alpine fir	100 "
Whitebark & limber pine	140 "
Cottonwood	100 "
Aspen	80 "

Calculation of the desirable average annual cut in each drainage was a four-step process as follows:

1. Forest Survey estimates of the allowable annual cut by types for counties or groups of counties were converted to a per-acre basis by dividing the total allowable cut of each species in each type by the area of that type. The per-acre allowable cut figures are presented in table 17 at the end of this report. They range from as low as 4 cubic feet a year to 59 cubic feet.

2. The average allowable cut-per-acre factor for each type in the county or group of counties was multiplied by the area of that type in the individual units. This procedure, of course, takes no account of the variation between units in site quality and, therefore, in timber-producing capacity. Such a refinement is impossible because site quality data are not available by units. With the large areas being dealt with here site differences tend to average out.

3. Corrections were then made in the cut estimates for management and utilization considerations which might affect yields.

   Current management thinking is that strips of timber should be left on each side of streams to provide protection for these streams. Cutting would be light in the strips. Analysis of several units has indicated that such special treatment along the streams would reduce total timber yields by less than 1-1/2 percent. To be on the safe side, calculated yields were reduced twice that amount or 3 percent.

   A 5-percent reduction was made in yield estimates to allow for logging waste. In other words, out of every 100 cords of standing timber, it is expected 5 cords will be unutilized due to breakage and other losses. An additional reduction of 5 percent was made to allow for deficiencies in utilization, in other words for trees included in the inventory which will never be logged. Although Forest Survey data give a good estimate of the wood which will ultimately be usable, the forest industries are currently not utilizing all of the timber considered merchantable by the survey.

4. The cubic-foot allowable cut data for each unit were converted to cords using the factor of 90 cubic feet of peeled wood in a 128-cubic-foot cord of wood with the bark on. The cord is at best a rather indefinite unit, the volume of wood in it varying according to the size of the sticks and thickness of the bark. However, a factor of 90 cubic feet provides a safety margin for it is somewhat high for an average. Thus, it results in an underestimation of the allowable cut in cords.

   Table 18 shows the estimated sustainable cut by species in each working circle.

Anyone using the statistics in table 18 should bear in mind their limitations. Because of the method of determing the cut, the estimates for the minor species are likely to be considerably in error. They serve mainly to indicate the general level of cutting of these species which might be sustained. Another important point to remember is that the indicated average annual sustainable cut of a working circle may not reflect how much cutting should be done during the coming few years. It is merely the expected long-term timber production from the working circle expressed in terms of annual yield.

All of the timber in the 31 working circles is suitable for pulping. Moreover, practically all of it is pulpable with the sulfate process.

Table 10 on the opposite page shows that Douglas-fir is the only species which does not rate highly for at least one pulping process and even it makes satisfactory pulp. This information was obtained from the Forest Products Laboratory. Table 19 shows the sustainable cut in each unit available for pulping if some of the timber is reserved for other uses as indicated earlier.

With the exception of an area isolated by Yellowstone National Park we have assumed that right-of-way problems will not prevent utilization of the timber.

Working circles 8 and 9 lie at the headwaters of streams passing through Yellowstone National Park. These working circles have a total annual allowable cut (all products) of 22,000 cords. Unfortunately the only economical way to get this timber out is through the Park. The matter of whether logging trucks will be allowed to use Park roads to haul this timber has not been settled, so we have not included the timber in these units among the supplies tributary to any of the mill sites.

The logging cost estimate of $8.70 per cord is based on data collected in connection with pulpwood timber sale appraisals in 1948 and 1949.

Costs in general have risen considerably since then. On the other hand, pulpwood logging in this locality is still in the pioneering stages and there is every reason to suppose that the job can be done more efficiently than it has been done. Thus, the $8.70 appears realistic. Table 11 itemizes the logging expenses.

Table 11. Estimated cost of logging one cord of pulpwood

Felling, bucking, skidding, loading	$5.50
Depreciation and maintenance of logging equipment	1.00
Camp construction and maintenance	.20
Overhead	1.00
Slash disposal	.35
Erosion control	.05
Payroll taxes, insurance, etc.	.60
	$8.70

The same logging cost has been assumed for all working circles. Although the expenses for an individual operation may vary from year to year, there is reason to believe that with a given level of efficiency

Table 10. Suitability of Eastern Montana timber for paper pulp

Process	Species	Difficulty of pulping	Quality of unbleached pulp	Suitability of pulp
Sulfate	Lodgepole pine	Reduces readily	Very strong. Good color.	High grade Kraft and specialty wrapping papers and fiber board.
	Douglas-fir	Reduces readily	Fairly strong. Poor color.	Kraft wrapping papers and fiber board not requiring maximum strength.
	White spruce	Reduces readily	Very strong. Excellent color.	High grade Kraft wrapping papers and fiber board.
	Engelmann spruce	Reduces readily	Strong. Excellent color.	High grade Kraft wrapping papers and fiber board.
	Alpine fir	Reduces readily	Very strong. Excellent color.	High grade Kraft wrapping papers and fiber board.
	Limber pine	Reduces readily	Strong. Good color.	High grade wrapping papers and fiber board. (No commercial use to date.)
	Aspen	Reduces readily	Low strength. Excellent color.	Excellent for mixture with lodgepole, limber, and ponderosa pine pulp in quantities up to 25 percent.
Sulfite	Lodgepole pine	Reduces fairly readily	Strong. Excellent color.	Wrapping, book, and printing papers.
	Douglas-fir	Reduces with difficulty	Fair strength. Poor color.	Limited by poor color and content of pitch.
	White spruce	Reduces readily	Strong. Excellent color.	News, wrapping, book, high grade printing and bond papers. Dissolving and nitrating pulps.
	Engelmann spruce	Reduces readily	Strong. Excellent color.	News, wrapping, book, high grade printing and bond papers. Dissolving and nitrating pulps.
	Alpine fir	Reduces readily	Very strong. Excellent color.	News, wrapping, book, high grade printing and bond papers. Dissolving and nitrating pulps.
	Limber pine	Little known of properties.		
	Aspen	Reduces readily	Low strength. Excellent color.	Book and tissues.
Mechanical	Lodgepole pine	Reduces readily	Standard strength. Excellent color.	Blending with chemical pulp in making newsprint, wallpaper, toilet tissue, toweling, and paper board.
	Douglas-fir	Reduces readily	Fair strength. Poor color. Likely to contain pitch.	Papers and boards not requiring maximum strength and color. Use limited because of pitch.
	White spruce	Reduces readily	Standard strength. Excellent color.	All uses requiring ground wood.
	Engelmann spruce	Reduces readily	Standard strength. Excellent color.	All uses requiring ground wood.
	Alpine fir	Reduces readily	Standard strength. Excellent color.	Practically all uses requiring ground wood.
	Limber pine	Reduces readily	Standard strength. Good color. Likely to contain pitch.	Use limited because of pitch. Otherwise suitable for all normal uses.
	Aspen	Reduces readily	Fair strength. Excellent color.	Coarse grades insulating board, finer grades news, book, and specialty papers.

the cost at any particular time will be about the same from place to place. In contrast transportation may be much more expensive in one locality than another. For that reason this cost has been estimated separately for each unit.

Each of the more important proposed roads was analyzed independently to determine its cost. The cost of the rest of the proposed road network was estimated by factors taking into account difficulty of construction.

A complete road network was planned for 25 sample drainages to determine the miles of primary and secondary road required for logging. This analysis revealed that although a number of factors affect road mileage, there is a distinct relationship between acreage and miles. Following are the factors which came out of the analysis:

	Miles of primary and secondary road per 1000 acres of commercial forest
I. Fairly concentrated timber areas - 71 to 100 percent of the area suitable and available for logging.6/	2.4
II. Scattered timber areas - less than 71 percent of the area suitable and available for logging.6/	2.8
III. Face units - timbered mountain slopes facing out onto agricultural or range land and to which satisfactory main stem roads exist.	2.0

Each of the 296 management units was classified into one of the above three categories and the appropriate factor applied to the forest acreage to estimate the total required mileage of primary and secondary roads. The mileage of existing adequate roads was deducted from this figure, as well as the mileage of major proposed roads and existing roads requiring reconstruction. As mentioned previously the cost of the latter two categories was estimated road by road.

6/ In estimating the degree of concentration a line was drawn around the loggable area in each unit. The relationship was then determined between the total area and the area of intermingled nonforest and noncommercial forest lands.

Each unit was classified as to difficulty of secondary road construction, and the total cost of the residual portion of the road system, after the above subtractions, was based on the per-mile costs in table 12. Feeder road mileages were based on a factor of 4.5 miles per 1000 acres of commercial forest. This factor is an estimate of logging engineers. Each drainage was classified as to difficulty of feeder road construction and total costs determined from the per-mile rates in table 13.

Table 12. Cost of constructing secondary roads per mile-1950

Difficulty of construction	Dollars
Extra light	1,400
Light	2,400
Medium	4,200
Heavy	7,600
Extra heavy	12,600

Table 13. Cost of constructing feeder roads per mile - 1950

Difficulty of construction	Dollars
Extra light	400
Light	700
Medium	1,200
Heavy	2,200
Extra heavy	3,000

Road construction costs per cord in tables 8 and 20 were determined by dividing the total cost of the roads by the number of cords to be transported over these roads over a 100-year period. This differs from the usual national forest practice of charging the cost of the roads needed for a timber sale to the wood actually removed in that sale even though the roads serve for hauling other timber later on. It should be remembered, however, that even though we have used a broad base for amortizing the road cost, very much larger expenditures for this purpose will be required during the first few years then later because of the need for a big expansion of the road system at an early date.

Trucking costs cover the actual operation of the truck (including maintenance), maintenance of the roads to the standard of their original construction, and standby time.

Table 14 presents the basic data used in calculating these costs. They are based on a 50,000-pound truck hauling an average of 8 cords per load and are derived from "Practical Applications of Hauling Cost Data," by Roger Nelson (1948). This is a multilithed report prepared by the Forest Service for use in this region Nelson's data were increased 15 percent to bring them to the 1950 level. Truck operation

Table 14. Trucking costs for 50,000-pound truck carrying 8 cords per load - 1950

	Truck operation	Road maintenance	Standby time
	- -Per cord-mile- -		
Single lane unsurfaced, poor alignment	.174	.038	.56
Single lane unsurfaced, fair alignment	.149	.038	.56
Single lane unsurfaced, good alignment	.132	.038	.56
Single lane surfaced	.128	.038	.56
Double lane surfaced	.070	.038	.56

costs include all items related to actual running of the trucks except fuel taxes and licenses. Specifically, the items included are depreciation on trucks, interest on investment in trucks, tractors and tires, fire and theft insurance, public liability or damage insurance, collision insurance, fuel, lubrication, repairs, tires, drivers wages (including normal overtime and vacation allowances), social security tax, unemployment compensation, industrial insurance, and administration expenses. The road maintenance item includes all costs of maintaining roads and bridges in the original condition, including periodic replacement of culverts and such other facilities as they wear out.

To apply these basic costs it was assumed that one-third of the truck haul on primary and secondary roads within each drainage would be on single lane, unsurfaced roads of good alignment and two-thirds on single lane unsurfaced roads of fair alignment. On such a basis the average cost of hauling and maintanance on these roads would be 18.1 cents a cord-mile. Calculations for 25 sample drainages indicate an average hauling distance of .34 mile per 1000 acres (including the intermingled nonforest and noncommercial forest area). From these data hauling and road maintenance within the units (on primary and secondary roads) was determined to average 6.2 cents a cord per 1000 acres of area. To this was added a flat 56 cents a cord to allow for the time the trucks would be held up waiting for loading and unloading, etc.

We assumed that the feeder roads will be single lane, unsurfaced, with poor alignment. In that case truck operation and road maintenance would cost 21.2 cents a cord-mile. An average cost of 6 cents a cord for feeder road hauling was determined by multiplying the cord-mile figure by an estimated average hauling distance of .27 mile.

In calculating the truck transportation cost outside the units, it was assumed that the total road maintenance expense of 3.8 cents a cord-mile would have to be paid on Forest Service and private roads and that there would be no maintenance expense on state highways. In the case of county roads the assumption was that the operators would do some road maintenance amounting to about half the cost on Forest Service and private roads.

As we pointed out truck licenses and fuel taxes are not included in any of the preceding figures. It is estimated that fuel taxes will amount to about 11 cents a cord and use, license, and property taxes (on the trucks) to 18 cents for a total of 29 cents.

In calculating rail transportation costs intra-state pulpwood rates in effect in the State of Washington on April 10, 1951, were used.

How much it will cost to haul pulpwood by rail within Montana is purely a matter of speculation at this time. This would be an intra-state haul and in the absence of any purely local pulpwood traffic the Board of Railroad Commissioners of the State of Montana has not established appropriate rates. However, it seems likely that if and when Montana rates are established for internal shipments of pulpwood they will be fairly similar to those in effect in neighboring states. Table 15 shows the assumed rates used in this study.

Much of the pulpwood would have to be transported over two railroads to get to the manufacturing points we have considered in this study. For intra-state traffic this would result in increased transportation costs. Our study indicates that on the average the cost of transporting wood over two railroads would be about 80 cents a cord higher than the rates shown in table 15.

Loading of freight cars is estimated to cost 65 cents a cord.

Table 15. Assumed cost per cord of intra-state pulpwood shipments in Montana

Distance in miles		Cents per cord
Over	Not over	
	10	170
10	20	184
20	30	200
30	40	213
40	50	227
50	60	242
60	70	257
70	80	272
80	90	286
90	100	302
100	110	316
110	120	332
120	130	345
130	140	361
140	150	375
150	160	389
160	170	404
170	180	419
180	190	434
190	200	448
200	210	460
210	220	469
220	230	482
230	240	492
240	250	503
250	260	514
260	270	526
270	280	537
280	290	546
290	300	558
300	320	575
320	340	589
340	360	602
360	380	617
380	400	631

With truck and rail costs at the levels indicated in the previous pages it pays to reload the wood onto freight cars and haul it the rest of the way by train if the nearest rail siding to the timber is more than 40 miles from the pulp mill.

Truck transportation is more economical than rail transportation for short hauls but as the distance increases beyond 40 miles the advantage is more and more in favor of rail transportation. In actual practice the distance which wood is trucked when rail facilities are available also depends upon the number of round trips a truck can make in a day and other factors which could not be taken into account in this study. For that reason the 40-mile breaking point was used without exception in the study.

In these calculations the total cost of building or rebuilding the roads required for timber business has been charged to the timber cut.

Table 16. Average cost of pulpwood at three mill sites if different proportions of primary and secondary road cost is charged to timber products

	Charging:
	100% to timber
Three Forks	$22.54
Livingston	19.19
Great Falls	21.82
	67% to timber
Three Forks	$22.41
Livingston	19.04
Great Falls	21.63
	0% to timber
Three Forks	$22.15
Livingston	18.74
Great Falls	21.23

The fairness of doing that is debatable as most of the primary and secondary roads to be constructed will be used for recreation, mining, transporting livestock and other purposes in addition to logging. A sample of the roads on the present transportation plan for the Eastern Montana national forests indicates that when these roads were planned a few years ago it was contemplated that only four-tenths of their value would be for timber hauling. This figure is no doubt low for we are now considering a more extensive timber development than was invisioned at that time. Transportation planning data do indicate, however, that most roads serve other purposes than logging and there is logical basis for charging less than 100 percent of the construction cost of primary and secondary roads to the timber. One point of view is that the cost of the basic road network is part of the management cost and should not be charged to the timber production operation. Table 16 shows that a small saving can be made in pulpwood production costs by reducing the charge for roads.

The stumpage and stand improvement charge of $2.00 a cord in the preceding figures is an estimate of the initial rates for the offering of a large sale of national forest timber for local pulp-mill development.

Where there are market values for pulpwood delivered at mill yards, the price of national forest stumpage (including stand improvement payments) is determined by deducting the costs of production from market value and dividing the remainder into an allowance for profit and risk to the producer and a stumpage fee to the government. No market value for pulpwood at the mill yard in Montana exists. There must, therefore, be some degree of arbitrary selection of pulpwood rates for initial sale to a Montana mill. However, it would be unwise to establish a mill in this area on a basis which could not afford at least a $2.00-a-cord cost for stumpage. In any event when pulp mills are established in Eastern Montana they will be expected to make manufacturing cost data available so equitable stumpage rates can be determined.

In considering the wood procurement costs presented in this report the possibility for more economical operation should not be overlooked.

There is considerable opportunity to develop more efficient logging methods as pulpwood operators gain experience with Eastern Montana conditions. For example, transportation of wood on overhead wires is a method with considerable promise (3). There are many steep and rocky slopes in the forest of Eastern Montana making both skidding and road construction expensive. If methods of aerial "skidding" on lightweight suspended cables now being experimented with in Canada and elsewhere prove adaptable to Eastern Montana conditions they may be the answer to more economical logging under certain circumstances.

Road construction costs per cord are relatively low compared with hauling costs. This suggests that the total cost per cord can be lowered in some instances by building higher standard roads than we have planned. Conversely, the total cost may be higher if poorer roads are built. Quality of a road makes a big difference in trucking costs. Turn to table 14 and you will see that the difference in trucking cost between a single lane unsurfaced road of poor alignment and a single lane surfaced road is 4.6 cents a cord-mile. For a truck load of wood hauled 10 miles that amounts to $3.68.

Construction of branch rail lines into some localities would reduce the transportation charge. Establishment of lower rail rates than those assumed in this study would also make for cheaper pulpwood. There are relatively few sites in Eastern Montana suitable for pulp mills because of the large water flow required to avoid pollution. That situation contributes to the high cost of transportation. If the water pollution potential of pulp mills could be eliminated or drastically reduced some plants could be located on smaller streams nearer to the timber, thus reducing the cost of the wood.

Table 17. Allowable annual cut per acre in four Forest Survey blocks in Eastern Montana[1/]

Forest Survey block and county	Type	Ponderosa pine	Douglas-fir	Alpine fir	Spruce	Lodgepole pine	White bark and limber pine	Cotton-wood	Aspen	Total
		Cubic feet per acre								
Block I	Ponderosa pine	5.23	1.09	--	--	--	--	--	--	6.32
	Douglas-fir	0.47	7.35	--	0.17	--	--	--	--	7.99
	Spruce	--	0.31	3.44	5.63	0.20	0.35	--	--	9.93
	Lodgepole pine	--	1.22	5.21	3.63	12.02	1.48	--	--	23.56
	Cottonwood	--	--	--	--	--	--	20.13	0.04	20.17
	Aspen	--	--	--	--	--	--	--	12.64	12.64
Block II										
Beaverhead	Alpine fir	--	--	10.64	--	10.65	5.32	--	--	26.61
	Douglas-fir	--	11.45	0.20	0.28	0.77	0.18	--	0.07	12.95
	Spruce	--	2.55	4.17	32.84	8.15	2.41	--	--	50.12
	Lodgepole pine	--	3.04	1.48	2.72	28.18	0.66	0.01	0.04	36.13
	White bark and limber pine	--	--	2.94	3.98	3.25	8.60	--	--	18.77
	Aspen	--	5.50	--	--	--	--	--	23.61	29.11
Broadwater	Douglas-fir	0.16	10.41	0.19	0.28	0.69	0.16	--	0.06	11.95
	Lodgepole pine	--	2.88	0.88	1.89	21.14	0.60	0.03	0.07	27.49
	Cottonwood	--	--	--	--	--	--	16.82	--	16.82
Deerlodge	Douglas-fir	--	13.06	0.42	0.42	0.84	--	--	--	14.74
	Spruce	--	--	11.86	35.59	11.86	--	--	--	59.31
	Lodgepole pine	--	3.05	0.91	2.01	22.26	0.62	0.03	0.07	28.95
Gallatin	Douglas-fir	--	12.02	0.22	0.47	0.76	0.22	--	0.06	13.75
	Spruce	--	2.84	6.16	29.51	5.57	2.97	--	--	47.05
	Lodgepole pine	--	4.52	1.88	3.71	35.59	0.78	0.03	0.03	46.54
	White bark and limber pine	--	--	3.51	4.72	3.79	10.08	--	--	22.10
	Aspen	--	6.14	--	--	--	--	--	26.70	32.84
Jefferson	Ponderosa pine	8.43	0.98	--	--	--	--	--	--	9.41
	Alpine fir	--	--	4.61	4.61	--	--	--	--	9.22
	Douglas-fir	0.09	16.24	0.18	0.33	0.64	0.11	--	0.05	17.64
	Spruce	--	2.46	4.94	28.39	6.17	2.46	--	--	44.42
	Lodgepole pine	--	2.70	0.81	1.76	19.61	0.55	0.03	0.06	25.52
	White bark and limber pine	--	--	0.77	2.30	1.53	11.49	--	--	16.09
	Aspen	--	3.15	--	--	--	--	--	15.73	18.88
Lewis and Clark	Ponderosa pine	8.10	0.88	--	--	--	--	--	--	8.98
	Douglas-fir	0.06	11.10	0.20	0.56	0.67	0.23	--	0.05	12.87
	Spruce	--	2.48	3.50	36.01	8.61	2.38	--	--	52.98
	Lodgepole pine	--	1.20	1.61	2.35	26.09	0.53	0.01	0.01	31.80
	Aspen	--	3.23	--	--	--	--	--	16.54	19.77
Madison	Alpine fir	--	--	10.95	10.95	--	4.38	--	--	26.28
	Douglas-fir	--	11.84	0.21	0.41	0.76	0.21	--	0.06	13.49
	Spruce	--	2.48	4.76	29.13	6.44	2.38	--	--	45.19
	Lodgepole pine	--	3.46	1.88	3.36	31.61	0.38	--	--	40.69
	White bark and limber pine	--	2.57	--	3.54	2.78	7.49	--	--	16.38
	Aspen	--	--	--	--	--	--	--	24.90	24.90
Meagher	Ponderosa pine	9.12	0.99	--	--	--	--	--	--	10.11
	Douglas-fir	0.09	11.02	0.20	0.27	0.74	0.16	0.05	0.09	12.62
	Spruce	--	2.49	4.13	32.86	8.13	2.37	--	--	49.98
	Lodgepole pine	--	2.76	1.37	2.49	25.88	0.60	0.01	0.04	33.15
	White bark and limber pine	--	--	2.78	3.85	2.99	8.12	--	--	17.74
	Aspen	--	3.01	--	--	--	--	--	16.55	19.56
Silver Bow	Alpine fir	--	--	10.32	10.32	--	3.44	--	--	24.08
	Douglas-fir	--	12.86	0.24	0.18	0.91	0.18	--	0.09	14.46
	Spruce	--	2.23	5.21	26.04	5.21	2.22	--	--	40.91
	Lodgepole pine	--	3.22	0.95	2.14	23.51	0.67	0.03	0.07	30.59
	Aspen	--	6.23	--	--	--	--	--	29.93	36.16
Block III	Ponderosa pine	8.15	0.07	--	--	--	--	--	0.01	8.23
	Alpine fir	--	--	8.58	9.65	--	2.91	--	--	21.14
	Douglas-fir	--	13.56	0.11	0.70	1.01	0.19	--	--	15.57
	Spruce	--	1.06	4.05	40.04	4.59	0.69	0.38	--	50.81
	Lodgepole pine	--	1.06	1.13	2.21	31.47	0.97	--	--	36.84
	White bark and limber pine	--	0.28	3.20	1.65	0.62	24.61	--	--	30.36
	Cottonwood	--	0.60	--	--	--	--	20.35	--	20.95
	Aspen	--	0.95	--	--	--	--	--	4.52	5.47
Block IV	Ponderosa pine	3.96	0.29	--	0.02	--	--	--	--	4.27
	Douglas-fir	0.05	4.77	0.06	0.34	1.05	0.13	--	--	6.40
	Aspen	--	0.98	--	9.31	2.94	--	--	--	13.23
	Lodgepole pine	--	1.36	0.08	0.72	11.19	0.12	--	--	13.47
	Cottonwood	--	0.01	--	--	--	--	5.72	1.10	6.83

1/ The following counties are in the portions of the Forest Survey blocks on this pulpwood study: Block I, Glacier, Pondera, Teton; Block II, as shown in table; Block III, Carbon, Golden Valley, Park, Stillwater, Sweetgrass, Wheatland; Block IV, Cascade, Chouteau, Fergus, Judith Basin.

Table 18. Annual sustainable cut in each working circle available for all timber products

No.	Working circle Name	Species: Ponderosa pine	Douglas-fir	Alpine fir	Spruce	Lodgepole pine	Whitebark & limber pine	Cotton-wood	Aspen	Total
						-Cords-				
1	Big Hole	--	21,005	8,077	16,242	145,197	3,372	42	250	194,185
2	Beaverhead	--	11,898	2,778	5,197	50,421	1,269	17	116	71,696
3	Ruby	--	8,257	642	1,211	8,480	242	--	1,361	20,193
4	Madison	--	12,122	2,044	4,422	29,682	590	--	540	49,400
5	Madison Basin	--	5,185	1,768	3,821	31,205	728	24	31	42,762
6a	Gallatin (South)	--	11,150	3,446	7,985	54,755	1,393	39	424	79,192
6b	Gallatin (North)	--	9,395	1,005	2,182	15,858	499	13	371	29,323
7	Yellowstone	--	19,131	1,202	3,598	28,154	1,099	7	15	53,206
8	Cooke	--	67	72	140	1,996	62	--	--	2,337
9	Absaroka	--	613	917	5,686	12,444	450	46	--	20,156
10	Shields	--	7,912	802	1,716	16,480	544	6	154	27,614
11	Big Timber	36	13,798	1,115	4,467	19,357	821	23	24	39,641
12	Beartooth	25	1,510	508	1,593	12,103	394	7	46	16,186
13	Rock Creek	--	398	353	695	9,848	304	--	79	11,677
14	Butte	--	3,912	390	793	8,527	274	12	44	13,952
15	Whitehall	33	12,560	978	2,009	17,656	572	16	75	33,899
16	Boulder	43	11,418	1,261	2,738	28,645	850	43	120	45,118
17	Anaconda	--	354	106	234	2,587	72	3	8	3,364
18	Helena	2,917	20,365	1,717	3,036	25,860	869	18	150	54,932
19	Townsend	278	11,277	558	1,145	9,706	405	12	81	23,462
20	Smith River	84	6,156	540	935	8,737	270	28	56	16,806
21	Canyon Ferry	2,648	6,571	271	557	3,914	203	4	39	14,207
22	Musselshell	492	5,882	897	1,709	16,026	436	20	158	25,620
23	White Sulphur Springs	33	7,067	1,571	3,927	25,470	741	28	507	39,344
24	Belt Creek	1,451	6,163	642	1,972	20,313	414	12	51	31,018
25	Highwood	27	802	22	180	2,364	37	--	164	3,596
26	Judith River	662	4,477	94	775	7,634	170	--	4	13,816
27	Snowy Mountains	90	383	11	91	1,200	19	--	--	1,794
28	Marias	25	800	1,854	1,407	4,022	506	--	77	8,691
29	Teton	33	710	937	898	1,601	220	--	73	4,472
30	Sun River	12	3,015	1,157	5,032	13,124	543	4	83	22,970
31	Dearborn	9	2,527	1,122	2,237	16,919	417	6	176	23,413
	Total	8,898	226,880	38,857	88,630	650,285	18,785	430	5,277	1,038,042

Table 19. Annual sustainable cut in each working circle available for pulping

Working circle No.	Name	Species: Douglas-fir	Alpine fir	Spruce	Lodgepole pine	Whitebark & limber pine	Aspen	Total
					-Cords-			
1	Big Hole	10,499	8,077	12,995	116,157	1,688	224	149,640
2	Beaverhead	5,905	2,778	4,159	40,335	636	104	53,917
3	Ruby	4,128	642	969	6,784	119	1,226	13,868
4	Madison	6,061	2,044	3,537	23,744	297	489	36,172
5	Madison Basin	2,591	1,768	3,056	24,964	364	29	32,772
6a	Gallatin (South)	5,575	3,446	6,389	43,804	720	381	60,315
6b	Gallatin (North)	4,698	1,005	1,747	12,687	249	334	20,720
7	Yellowstone	9,565	1,202	2,879	22,523	1,239	13	37,421
8	Cooke	34	72	112	1,597	31	--	1,846
9	Absaroka	307	917	4,549	9,955	224	--	15,952
10	Shields	3,957	802	1,399	13,183	272	139	19,752
11	Big Timber	6,900	1,115	3,572	15,485	444	21	27,537
12	Beartooth	754	508	1,273	9,682	196	41	12,454
13	Rock Creek	199	353	556	7,879	152	71	9,210
14	Butte	1,955	390	634	6,821	137	40	9,977
15	Whitehall	6,281	978	1,607	14,124	287	68	23,345
16	Boulder	5,706	1,261	2,189	22,917	424	107	32,604
17	Anaconda	177	106	187	2,070	36	7	2,583
18	Helena	10,184	1,717	2,427	20,689	435	135	35,587
19	Townsend	5,639	558	915	7,764	201	71	15,148
20	Smith River	3,079	540	748	6,989	134	49	11,539
21	Canyon Ferry	3,286	271	445	3,130	102	35	7,269
22	Musselshell	2,942	897	1,366	12,821	217	142	18,385
23	White Sulphur Springs	3,534	1,571	3,140	20,375	442	456	29,518
24	Belt Creek	3,158	642	1,579	16,249	206	47	21,881
25	Highwood	401	22	145	1,890	17	148	2,623
26	Judith River	2,239	94	620	6,108	84	4	9,149
27	Snowy Mountains	191	11	72	960	9	--	1,243
28	Marias	499	1,854	1,125	3,072	273	69	6,892
29	Teton	355	937	719	1,280	110	66	3,467
30	Sun River	1,507	1,157	4,037	10,594	272	76	17,643
31	Dearborn	1,263	1,122	1,789	13,534	208	158	18,074
	Total	113,569	38,857	70,936	520,166	10,225	4,750	758,503

Table 20. Pulpwood procurement costs for three mill sites by working circles

Working circle No.	Name	Road construction	Haul-ing inside unit	Hauling unit to mill	Logging	Margin for profit and risk	Stumpage and timber stand improvement	Total
		--Dollars per cord--						
To Great Falls								
16	Boulder	.63	2.46	4.77	8.70	1.83	2.00	20.39
18	Helena	.81	2.74	4.18	8.70	1.81	2.00	20.24
19	Townsend	.87	2.20	6.62	8.70	2.00	2.00	22.39
21	Canyon Ferry	1.20	2.61	5.38	8.70	1.93	2.00	21.82
24	Belt Creek	1.30	2.73	7.19	8.70	2.12	2.00	24.04
25	Highwood	1.42	1.92	5.30	8.70	1.87	2.00	21.21
26	Judith River	2.01	3.03	6.19	8.70	2.08	2.00	24.01
27	Snowy Mtns	1.25	1.58	6.86	8.70	1.99	2.00	22.38
28	Marias	1.01	2.01	7.11	8.70	2.04	2.00	22.87
29	Teton	.99	1.57	7.02	8.70	1.99	2.00	22.27
30	Sun River	.84	2.35	6.81	8.70	2.04	2.00	22.74
31	Dearborn	.57	3.05	5.71	8.70	1.98	2.00	22.01
To Three Forks								
1	Big Hole	.54	2.54	8.70	8.70	2.22	2.00	24.70
2	Beaverhead	.72	2.46	8.64	8.70	2.21	2.00	24.73
3	Ruby	.93	2.23	6.48	8.70	1.99	2.00	22.33
4	Madison	.73	2.22	5.01	8.70	1.83	2.00	20.49
5	Madison Basin	.28	2.30	7.50	8.70	2.07	2.00	22.85
6a	Gallatin (S)	.51	2.30	4.42	8.70	1.77	2.00	19.70
14	Butte	.59	2.73	4.95	8.70	1.86	2.00	20.83
15	Whitehall	.65	2.31	3.07	8.70	1.73	2.00	18.46
17	Anaconda	.55	1.78	7.01	8.70	1.98	2.00	22.02
20	Smith River	.79	1.88	5.69	8.70	1.87	2.00	20.93
22	Musselshell	.65	2.36	5.07	8.70	1.85	2.00	20.63
23	White Sulphur Springs	.62	2.49	5.06	8.70	1.86	2.00	20.73
To Livingston								
6b	Gallatin (N)	.77	1.98	2.87	8.70	1.60	2.00	17.92
7	Yellowstone	.86	2.13	2.95	8.70	1.63	2.00	18.27
8	Cooke	.29	1.41	6.50	8.70	1.88	2.00	20.78
9	Absaroka	.78	2.63	7.75	8.70	2.15	2.00	24.01
10	Shields	.64	2.02	4.29	8.70	1.74	2.00	19.39
11	Big Timber	1.08	2.11	3.94	8.70	1.74	2.00	19.57
12	Beartooth	.46	1.68	7.01	8.70	1.97	2.00	21.82
13	Rock Creek	.52	1.89	5.71	8.70	1.86	2.00	20.68

Table 21. Cost of pulpwood delivered to nearest railroad spur

	Working circle	Cost at spur
		Dollars per cord
1	Big Hole	20.20
2	Beaverhead	19.66
3	Ruby	18.98
4	Madison	18.45
5	Madison Basin	20.25
6a	Gallatin (South)	17.28
6b	Gallatin (North)	16.04
7	Yellowstone	16.72
8	Cooke	17.71
9	Absaroka	20.94
10	Shields	17.33
11	Big Timber	18.88
12	Beartooth	18.37
13	Rock Creek	15.84
14	Butte	16.62
15	Whitehall	16.28
16	Boulder	16.02
17	Anaconda	17.55
18	Helena	16.97
19	Townsend	16.80
20	Smith River	17.56
21	Canyon Ferry	17.88
22	Musselshell	17.03
23	White Sulphur Springs	17.36
24	Belt Creek	21.30
25	Highwood	17.94
26	Judith River	20.59
27	Snowy Mountains	18.23
28	Marias	18.13
29	Teton	19.17
30	Sun River	19.66
31	Dearborn	18.94

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